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EARLY SPRING BUDDING BY THE PLATE METHOD[1]

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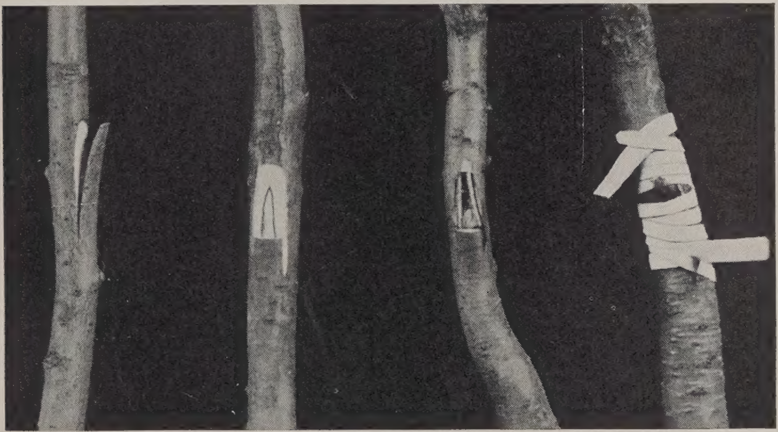
During recent dry years nurserymen and others propagating fruit trees have, in many cases, obtained a very unsatisfactory stand. At the Morden Experimental Station extensive propagation experiments have been conducted throughout the year using various methods. One method in particular which has proven to be of practical value is the "plate method" of budding as credited to J. F. Jones (1) of Pennsylvania.

Kains (2) describes plate budding and several variations. Although differing in some respects to that described by Yerkes (1) as the Jones Method the general principal is quite similar.

At Morden plate budding has been more commonly termed Jones budding, after Yerkes. In order to eliminate some confusion with the Patch method, for which Jones developed a special tool, it is here referred to as a form of plate budding. Chipman (3) refers to this method as Jones or dry budding. Patterson (4) describes it as dry budding.



A B C D

FIGURE 1. Plate budding. a. Downward cut through bark. b. Tip of flap removed. c. Bud inserted behind flap. d. Bud tied.

[1] Presented before a meeting of the Horticultural Group of the C.S.T.A. at the University of Saskatchewan, Saskatoon, Sask., June 28–30, 1937.

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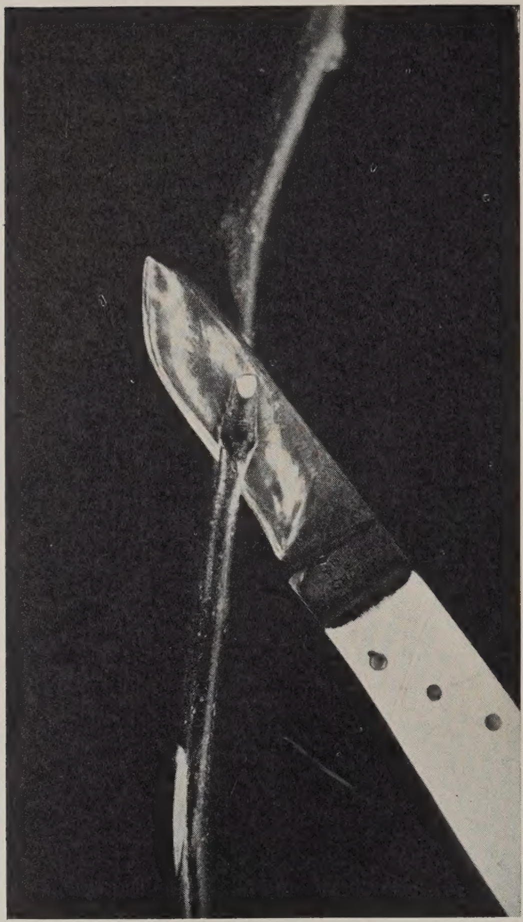

FIGURE 2. Removing bud. Note "Wedge cut" base of bud made by downward stroke of knife before cutting off bud.

Upshall (5) in propagation experiments used some plate budding. In correspondence Upshall (6) refers to the method used here, as the plate bud introduced by Jones.

This plate method of budding, to the writer's knowledge, had not been used by nurserymen on the Canadian prairies prior to 1933. Experiments with it have been conducted at this station since that date and at present nurserymen are widely using it and obtaining satisfactory stands under adverse conditions.

Plate Method of Budding

This method of budding is considered more rapid and more easily done by the average person. At first it may seem rather awkward to one experienced to the more common shield or T method. A little practice, however, usually puts it in favour.

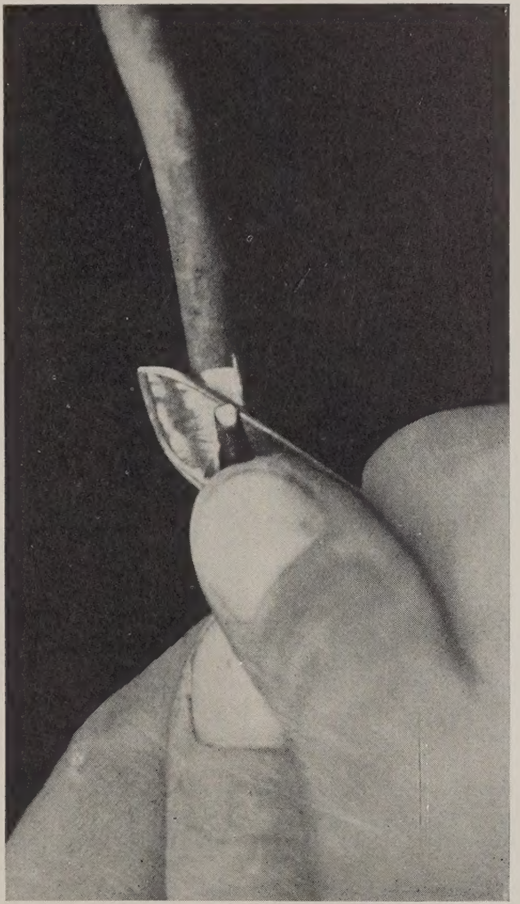

FIGURE 3. Inserting bud behind flap by shoving off back of knife with thumb.

The operation is quite simple as shown in Figure 1. A section of the bark is pared from the side of the stock, by a single downward stroke of the knife, leaving the lower end attached to the stock (Figure 1 a). The wood should not be cut into deeply unless necessary to accommodate a large bud. The depth of cut is of major importance (7). Cuts too shallow (not quite to the wood) or too deeply into the wood result in a lower percentage stand. After a little practice one is able to make a cut in the stock which closely coincides with the cut surface of the bud. The upper part of the strip of bark is cut off leaving sufficient "flap" to come well up on, but not cover, the dormant bud (Figure 1 b). The bud is cut as for the shield method and placed behind the flap against the cut surface of the stock (Figure 1 c), the flap tending to hold the bud until tied. The bud is then tied as shown in (Figure 1 d) and ultimately cared for similar to the shield methods.

Figure 2 illustrates the Morden method of removing the bud with "wedge cut" base. The bud may then be inserted behind the flap as shown in Figure 3, or with the fingers as commonly practised.

The Season of Budding

Unlike the common shield method of budding it is not necessary for rapid successful budding to have the bark of the stock "slipping" when budding by the plate method. One advantage of this is the prolonging of the budding season, which frequently under dry conditions is much too short.

Budding experiments during the past three years demonstrate that early spring budding is a satisfactory method of propagation under prairie conditions. Although not usually gaining quite one year, the young early spring-budded trees are larger and better branched the second year than the later summer-budded stock. Winter mortality of buds, which frequently is of considerable importance, is eliminated. It is not unusual for plum and sandcherry, and even apple and crabs, to shoot into growth the same season even though budded in August, using current season's buds. Severe winters kill the late tender shoots of some varieties, resulting in a poor percentage stand. It is quite possible with early spring budding and favorable growing conditions to have saleable stock five months after budding, thus gaining one year over summer budding. Budding may also be done at a season of the year when other work is not so pressing.

*Weather Conditions During and Immediately Following Budding in 1936**

The lowest temperature recorded for the month of April was on the seventh when $-14°$ F. was registered. Over 20 degrees of frost was registered after building on the sixteenth. The lowest in May was 10 degrees of frost on the ninth. Budding done on the same day gave an average of 83.6% stand. On May 10 five degrees of frost was officially registered.

At the time of the first budding on April 6 considerable snow was present in snow-trap areas and the frost was only partially out of the surface soil around the stock. Below this the soil was frozen solid to an indefinite depth.

Condition of Stock on Budding Dates

Spring budding during 1936 was done on April 16, May 9, May 11, and May 16 as shown in Tables 1 and 2. On April 16 buds on stock were completely dormant. The leaf buds on the stock on May 9 were in the "squirrel ear" stage, and by May 16 had unfolded.

Results of 1936 Spring Budding

Table 1 illustrates the results obtained with some recent Morden apple introductions budded April 16, May 9, and May 16. Results with scions of four varieties of apples from the Central Experimental Farm, Ottawa, six varieties of pear scions from David Tait, Carterton, Ontario, two varieties of pear scions from the Minnesota Fruit Breeding Station, Tecumseh Plum and 0-3-34a sandcherry scions from local trees are given in Table 2. All scions were stored under two to four inches of damp sphag-

* All temperatures given are minimum for the various dates as recorded on official thermometers in degrees Fahrenheit on the grass.

TABLE 1.—SPRING BUDDING ON COLUMBIA SEEDLINGS USING FALL CUT SCIONS

Variety	Budded	Treatment	No. budded	No. growing	Per cent growing
Breakey	April 16/36	1 2	25 25	23 21	92 84
Breakey	May 9/36	1 2	25 25	23 23	92 92
Breakey	May 16/36	1 2	25 25	23 24	92 96
Redant	April 16/36	1 2	25 25	19 21	76 84
Redant	May 9/36	1 2	25 25	23 22	92 88
Redant	May 16/36	1 2	25 25	20 16	80 64
Ostem	April 16/36	1 2	25 25	12 17	48 68
Ostem	May 9/36	1 2	25 25	20 19	80 76
Ostem	May 16/36	1 2	25 25	18 18	72 72
Morden 341	April 16/36	1 2	25 25	16 15	64 60
Morden 341	May 9/36	1 2	25 25	15 19	60 76
Morden 342	April 16/36	1 2	25 25	17 13	68 52
Morden 342	May 9/36	1 2	25 25	22 21	88 84
Morden 343	April 16/36	1 2	25 25	21 19	84 76
Morden 343	May 9/36	1 2	25 25	24 20	96 80
Morden 343	May 16/36	1 2	25 25	21 22	84 88

Average all varieties	—	No. budded	No. growing	Per cent growing
Average all dates	1 2	400 400	317 310	79.25 77.50
Average treatments 1 and 2	April 16/36 May 9/36 May 16/36	300 300 200	214 251 162	71.33 83.67 81.00

TABLE 2.—SOME ADDITIONAL RESULTS, 1936

Fruit	Variety	Scion source	Stock	Budded	Treat-ment	No. budded	No. growing	Per cent growing
Apple	Okanagan	C.E.F., Ottawa	Columbia sdlgs.	May 9/36	1	25	25	100.0
	Geneva	C.E.F., Ottawa	Columbia sdlgs.	May 9/36	1	25	25	100.0
	Louise	C.E.F., Ottawa	Columbia sdlgs.	May 9/36	1	25	23	92.0
	Scugog	C.E.F., Ottawa	Columbia sdlgs.	May 9/36	1	25	20	80.0
Sandcherry Plum	0-3-34a	M.E.S.			1	32	3	9.4
	Tecumseh	M.E.S.			1	54	9	16.7
Pear	Noblite	Tait, Carterton	Avoidea sdlgs.	May 11/36	1	6	4	66.7
	Menie	Tait, Carterton	Avoidea sdlgs.	May 11/36	1	22	17	77.3
	Miney	Tait, Carterton	Avoidea sdlgs.	May 11/36	1	21	19	90.5
	Beierschmitt	Tait, Carterton	Avoidea sdlgs.	May 9/36	1	25	21	84.0
	Patten No. 1215	Tait, Carterton	Avoidea sdlgs.	May 9/36	1	11	8	72.7
	Early Russian	Tait, Carterton	Avoidea sdlgs.	May 9/36	1	9	7	77.8
	Parker	M.F.B. Station	Avoidea sdlgs.	May 9/36	1	35	18	51.4
	Minn. No. 3	M.F.B. Station	Avoidea sdlgs.	May 9/36	1	35	20	57.1

NOTE.—Plum and Sandcherry scions in poor condition (showing 50% colour).

TREATMENT (of stock).—1. Stock cut to half when budded. 2. Stock uncut when budded. All stock cut back to stub May 30, 1936.

METHOD.—All budding done, "plate method wedge cut". Stock in "squirrel ear" stage on May 9, 1936.

num moss on the floor of a common storage basement. The storage temperature ranging between 30° and 45° F. In some cases, especially with the plums and sandcherries, the moss was too damp, resulting in most buds swelling and showing considerable colour before budding dates. From close observations on top-grafting and spring budding the writer has noted that scions on which the buds are showing green do not, as a rule, give a satisfactory stand. It will be observed that, in general, the stand was fair to good with the exception of Tecumseh and 0-3-34a.

It will also be observed that although a fair stand was obtained from April budding the stand in May was generally better. Removing part of the stock at time of budding has usually resulted in an increase in the percentage of buds to grow. This has been more marked when budding during dry periods (7).

Remarks on 1937 Experiments

The promising results obtained in 1936 stimulated more interest in spring budding this year. A total of over 4,000 buds including 91 varieties of apples and crabs, 7 varieties of plums, 1 apricot, 1 sour cherry and 6 lilacs have been budded. This date (June 25) is too early for complete data on stand. At the present time, however, still more promising results are appearing with some varieties of crabs and apples showing 100% and plums up to 80% growing. As in 1936, May budding appears to be preferable to April. Budding in June has given some good "catches", but being so much later the stand is still questionable. The shield method of budding has been used with equal success as compared with the plate method in June. With the plate method the ease of inserting a bud without a petiole is a consideration. Ornamentals such as lilacs and roses may also be propagated successfully by this method.

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PRELIMINARY TESTS WITH SOFTWOOD CUTTINGS OF TREES AND SHRUBS IN ALBERTA[1]

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Nurserymen at the present time in Alberta practice propagation by means of cuttings with only a few kinds of outdoor plants. It has been their custom to import lining-out plants, usually from Holland, and grow them to salable size. The imported stock has given fairly good, but by no means completely satisfactory, results. Many kinds of plants are now readily available in the province which have not been propagated by cuttings because they have not been tried. Cuttings may be of several kinds, but the discussion here is restricted to certain phases of softwood cuttings.

MATERIALS AND METHODS

The purpose of the tests reported here is, in general, an attempt to indicate the practicability of propagation by softwood cuttings of trees and shrubs grown under Alberta conditions. The main factors considered are: proper time to gather the cuttings, best type of medium, optimum temperature for rooting, suitable place of the basal cut, and, above all, to determine the kinds which root most readily.

Stage of Maturity

The stage of maturity at which green wood roots most readily varies greatly with different genera and different climatic conditions. In the effort to obtain information as to the proper season to take cuttings from the many kinds of ornamental plants at Edmonton, the tests were started as soon as new growth had become sufficiently mature. The first cuttings were gathered and placed in the frames about June 15. After a month's time a second lot was taken. Precautions were taken to prevent wilting or drying-out while gathering and preparing the cuttings prior to placing in the rooting frames. The cuttings were put in a pail of water immediately after they were taken and allowed to stand in the water while being prepared. After planting, they were well watered-in. The leaves were syringed at frequent intervals during the day and the walks and platforms were kept moist to maintain a high relative humidity, for if cuttings become wilted it is extremely difficult to restore their original turgidity. In mid-June, when the first lot of cuttings was taken, the more mature, slower-growing wood was selected in preference to the more succulent. At this time, some difficulty was encountered in preventing the softer material from wilting.

The rooting bench, situated in the greenhouse, consisted of three frames placed end to end and covered with sash. White canvas duck, suspended on wire above the frames, was used as a shade. The first frame served as a check. The other two portions were supplied with bottom heat by means of electricity, with the temperature thermostatically controlled. Each of the three frames was in turn subdivided into three to allow for three types of rooting media.

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[1] Presented before a meeting of the Horticultural Group of the C.S.T.A. at the University of Saskatchewan, Saskatoon, Sask., June 28–30, 1937.

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FIGURE 1. One section of Rooting frame, with the three types of media, sand, sand-peat mixture, and peat respectively.

Sand has unquestionably been the most widely used and recommended of all materials for rooting purposes. With certain plants there is the tendency to replace sand with other media, such as peat or a mixture of peat and sand. Because both peat and sand are easily obtained in the West, they have been used as the basis of this investigation. In addition, a mixture of sand and peat, equal parts by volume, was included in the test. These three types of media were sterilized in a conclave prior to placing in the rooting frames. After placing in the frames, watering thoroughly, and allowing the surplus water to drain away, the pH was determined. The peat, sand, and sand-peat mixture showed pH reactions of 5.8, 7.5 and 6.8, respectively. According to results obtained by Hitchcock (2) the acid reaction of the peat (pH 5.8) should not be detrimental to the cuttings in any way; he found that cuttings withstood a pH range of 4.5 to 7.0 and that good rooting occurred.

Records were kept of the temperatures of the greenhouse and of the media within the frames. During the period of the experiment the temperature of the media in the check frame averaged around 60° F., but fluctuated considerably depending upon greenhouse temperature changes. The other two sections were maintained at a fairly constant temperature; one at 70° F., the other at 80° F.

The study included tests of the best place to make the basal cut. The three types of cuts used, when possible, were similar to those described by Chadwick (1) and Laurie and Chadwick (3); namely, at the node, one-half inch above the node, and one-half inch below the node.

Though this investigation has been conducted over a two-year period, using approximately 9,000 cuttings, it is considered preliminary in nature. Because of the lack of information and knowledge regarding the feasibility of this type of vegetative propagation, by western nurserymen, these trials

have been necessary prior to further investigation. The two-year period has not been sufficient as a thorough test, thus the results reported and discussed here provide only preliminary indications. Further investigation, including a number of technical angles, such as studies with root promoting substances, is under way.

DISCUSSION

Media

The results obtained do not strongly favour peat as a general rooting medium (Table 1). Only in a few cases did the peat result in a higher percentage of rooted cuttings. *Physocarpus opulifolius* (Ninebark), and Celastrus scandens (American Bittersweet) were the only two for which the peat appeared to be superior to the sand or the sand-peat mixture. The type of medium does not seem to play an important part in the rooting of *Parthenocissus quinquefolia* (Virginia Creeper), or *Parthenocissus quinquefolia engelmanni* (Self-Clinging Virginia Creeper), as the two rooted readily under all conditions.

TABLE 1.—EFFECT OF THREE MEDIA ON THE ROOTING OF SOFTWOOD CUTTINGS AND A NOTE ON THE BEST TEMPERATURE

Name of plant	Medium and percentage rooting			Best temperature
	Sand	Mixture	Peat	
Amorpha fruticosa	100	17	*	70° F.
Celastrus scandens	53	47	80	80°
Clematis tangutica	66	73	52	70°
Cornus stolonifera	93	53	53	70°
Lonicera tatarica	88	73	13	60–70°
Parthenocissus quinquefolia	100	80	100	60–70°
Parthenocissus quinquefolia engelmanni	86	91	82	70°
Philadelphus Lewisii	97	74	32	70°
Physocarpus opulifolius	60	100	100	60°
Sambucus melanocarpa	60	30	50	60–70°
Sambucus racemosus	75	62	34	60–70°
Sorbaria sorbifolia	80	80	40	60–70°
Spiraea arguta	60	10	0	60°
Spiraea Frobeli	85	60	40	60°
Spiraea media	61	20	46	70°
Spiraea Van Houttei	80	*	*	70°
Symphoricarpos albus	81	40	*	70°
Syringa villosa	80	12	6	70°
Syringa Josikaea	78	54	22	70°

* Not tested.

As a rule, a higher percentage of rooting was obtained in the sand or the sand-peat mixture than in the peat alone, with the sand usually being superior. A few general observations were made when the cuttings were removed at the end of the rooting period. In practically all cases, the roots on the cuttings in sand were larger in diameter, more numerous, and generally longer than those which developed in the mixture. The larger-sized roots in the sand may favour greater absorption when potted up or planted out. The general health and appearance of the cuttings were about equal in the sand and in the mixture as far as could be observed. They were much superior to those in peat. The roots developing on the cuttings in the mixture were invariably smaller in diameter, usually more

branched, and with a tendency to be more grouped at the base of the cutting. The same tendency was found in the peat as well, though less marked. It was further noted that a greater amount of callus formed on the cuttings in the peat. The only explanation that would seem related to this callus condition is the much higher water holding capacity of the peat. Since peat is very retentive of moisture, unless great care is exercised the rooting medium is liable to become excessively wet and result in rotting. For this reason, sand, or the mixture, both of which offer better aeration and drainage, usually are safer and more dependable rooting media for the inexperienced propagator.

These results indicate that, under the conditions of this experiment at least, sand is a more satisfactory general medium than peat. The mixture of sand and peat gave reasonably good results and in some respects is equal to sand. The peat, however, gave very unsatisfactory results.

Bottom Heat

Work done elsewhere has fully demonstrated the advantages that may be obtained from the application of bottom heat to encourage root formation. A safe guide is to provide 5° to 10° F. higher temperature in the rooting frame than under natural conditions. Aside from corroborating previous work, bottom heat was supplied in this experiment to

FIGURE 2. Rooting response of *Syringa villosa*. Upper right, rooting in sand at 60° F.; upper left, rooting results in sand at 70° F.; lower right, in mixture at 70° F.; and lower left, in peat at 70° F.

study its application to softwood cuttings of shrubs grown under Alberta conditions. The most favorable temperatures found for some of the shrubs worked with are listed in Table 1. Where a range of temperature, as from 60° to 70° F. has been given, it simply indicates that rooting has been equally good in the check frame at approximately 60° F., and in the number two frame at 70° F. As previously mentioned, the range of temperature studied was from 60° to 80° F. Results indicate quite definitely that 60° to 70° F. is the most satisfactory. The length and percentage of rooting and the appearance of the cuttings in the frames at 60° F., and at 70° F., were much superior to the 80° F. temperature. Some difficulty was encountered in maintaining sufficient turgidity in the frame at 80° F. Only in the case of *Celastrus scandens* did the temperature of 80° F. give a greater percentage of rooting.

Place of the basal cut

The results obtained on this phase of the work are very similar to those reported by Chadwick (1) in that most shrubs gave a greater percentage rooting when the basal cut was at the node or below. The most satisfactory place of basal cut as found in the present work is shown in Table 2. Of the species tried, only *Spiraea media* gave better results when the basal cut was above the node. The climbers or creepers tested appeared indifferent as to where the cut was made. *Spiraea bumalda Froebeli* and *Syringa villosa* gave better results when the cut was below the node. *Amorpha fruticosa*, *Philadelphus Lewisii*, *Physocarpus opulifolius*, *Spiraea arguta*, *Spiraea Van Houttei*, and *Symphoricarpos albus* gave better results when cut at the node. The remaining species gave equally good results whether cut at the node or below.

TABLE 2.—GUIDE TO THE BEST PLACE TO MAKE THE BASAL CUT AND THE BEST TIME TO GATHER CUTTINGS

Name of plant	Time to take cuttings	Place of basal cut
Amorpha fruticosa	June 30 – July 30	At node.
Celastrus scandens	June 30 – Aug. 15	Indifferent.
Clematis tangutica	June 30 – July 30	Indifferent.
Cornus stolonifera	June 30 – July 30	At or below node.
Lonicera tatarica	June 30 – July 30	At or below node.
Parthenocissus quinquefolia	June 15 – July 30	Indifferent.
Parthenocissus quinquefolia engelmanni	June 15 – July 30	Indifferent.
Philadelphus Lewisii	June 30 – July 30	At node.
Physocarpos opulifolius	June 30 – July 30	At node.
Sambucus melanocarpa	June 15 – July 30	Node or below.
Sambucus racemosus	June 30 – July 30	Node or below.
Sorbaria sorbifolia	June 15 – July 30	Node or below.
Spiraea arguta	June 15 – July 15	At node.
Spiraea Froebeli	June 15 – July 15	Below node.
Spiraea media	June 15 – July 15	Node or below.
Spiraea Van Houttei	June 15 – July 15	At node.
Symphorocarpos albus	June 30 – July 30	At node.
Syringa villosa	June 15 – July 15	Below node.
Syringa Josikaea	June 15 – July 15	Node or below.

Stage of Maturity

Failures may result from lack of knowledge as to the proper time to make greenwood cuttings. Considerable care must be exercised in selecting wood at the right stage of maturity, otherwise rooting takes place slowly

and extreme difficulty is encountered in preventing wilting. The cuttings are best taken from fairly mature shoots or portions of shoots rather than from the too soft, rapidly growing parts. When the wood is very soft, considerable trouble arises in preventing wilting of the leaves even with frequent syringing and maintenance of a high relative humidity. Due to wood maturity depending largely on climatic conditions, it is difficult to state, for any one species, any definite time to collect. This problem can best be solved from experience with the material. A wide range of time over which the cuttings may be taken is given in Table 2. This range is by no means final and should only be used as a guide, since the trials were not extensive enough to investigate this problem fully. Besides the percentage of cuttings which rooted when taken at different dates, the maturity of the wood was also taken into account in arriving at these dates.

In attempts to take leafy-shoot cuttings from deciduous shrubs after August 1, the problem arises of keeping the leaves intact. Since the greenwood cutting is largely dependent on the leaves manufacturing sufficient food for root growth, the percentage rooting is reduced.

Readiness or Ease of Rooting

Many more species were tested than is indicated in Table 1. When the percentage of rooting was less than 50% under any one treatment it was considered as unsatisfactory. Commercial propagation of these forms under conditions similar to these trials would likely be unprofitable. The species in question, as well as kinds that refused to root even up to 10 weeks in the frame, are simply listed in Table 3. The indications are that different, or more carefully controlled conditions, or the use of growth promoting substances will be necessary to induce rooting in these kinds.

TABLE 3.—SPECIES THAT ROOTED POORLY OR FAILED TO ROOT AT ALL

Percentage of rooting 50% or less	Roots failed to appear up to 10 weeks in the rooting frame
Berberis thunbergi	*Amelanchier alnifolia*
Caragana frutex (frutescens)	*Cotoneaster acutifolia*
Caragana lorbergii	*Crataegus crus-galli*
Caragana pygmaea	*Elaeagnus angustifolia*
Daphne cneorum	*Elaeagnus argentea*
Lonicera coerulea edulis	*Halimodendron halodendron*
Populus berolinensis	*Prunus cistena*
Potentilla fruticosa	*Prunus nana*
Spiraea media sericea	*Quercus macrocarpa*
Tamarix pentandra	*Shepherdia argentea*
	Shepherdia canadensis

With respect to the kinds that refused to root even up to ten weeks in the frames, it was observed that even at the end of this time most of the cuttings were still as fresh and nearly as green as when planted, with the exception of *Quercus macrocarpa* and *Crataegus crus-galli* in which the leaves had fallen off. This freshness was particularly noticeable in *Cotoneaster acutifolia*. This group is being further tested with the use of root promoting substances.

Some have claimed that softwood cuttings will not winter well under Alberta conditions. This factor has not been investigated as fully as could be desired so that this criticism can neither be fully denied or confirmed. However, our limited experience has shown that cuttings of hardy species, started early, well rooted, and planted so that they become established in the fall, will come through the winter. As an example, 15 cuttings of *Syringa villosa* were planted directly into the garden from the frames in mid-July. The winter of 1936–37 was hard on perennials due to lack of soil moisture and snow cover. The *Syringa villosa* cuttings came through the dry fall of 1936 and the succeeding winter in fine condition, indicating that perhaps the wintering problem may not be as serious as supposed. This problem is being further investigated during the 1937-38 season on a fairly comprehensive scale.

CONCLUSION

These preliminary tests demonstrate that many Alberta grown trees and shrubs can be propagated by means of greenwood cuttings. In most of the shrubs tested the stage of maturity which ensured good rooting covers a sufficient period of time to enable extensive use of this method of propagation. It is likely that wider application of softwood cuttings could be made use of by nurserymen in the West, with both profit to themselves and to the general public.

ACKNOWLEDGMENT

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Résumé

Essais préliminaires de boutures d'arbres et d'arbustes en Alberta. C. R. Ure, Université de l'Alberta, Edmonton, Alta.

Ces essais préliminaires démontrent que beaucoup d'arbres et d'arbustes cultivés dans l'Alberta peuvent être propagés au moyen de boutures de bois vert. Chez la plupart des arbustes éprouvés, la phase de maturité qui garantit un bon enracinage couvre un temps suffisant pour que l'on puisse faire un large emploi de cette méthode de propagation. Il est probable que les pépiniéristes de l'Ouest pourraient faire un plus large emploi de boutures de bois tendre, dans leur intérêt personnel et dans l'intérêt du public en général.

POLLINATION OF THE SHIRO PLUM[1]

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Ontario Horticultural Experimental Station, Vineland Station, Ont.

A search for a suitable pollen variety for the Shiro plum has brought to light an interesting observation. Burbank when growing beside Shiro does not seem to increase the set of fruit, yet when Shiro is hand pollinated with Burbank the set is very good. These varieties bloom at the same time.

Literature on the pollination of Shiro apparently is lacking, possibly because the variety is not widely grown. Since it has been generally accepted that Japanese plums would pollinate one another, Burbank and Shiro,[3] the two leading Japanese varieties in the Niagara district, were planted together. As pointed out by the writer in an article in Canadian Horticulture and Home Magazine of January, 1934, this combination did not prove satisfactory.

The fact that Shiro was not setting sufficient fruit was noted about 1930. In this particular case the Burbank trees were about four rows away from the Shiro row. It was suggested that perhaps the Burbank was too far away and if grafted into a few Shiro trees the results would be better. This grafting was done and when the grafts bloomed, although they themselves set tremendous crops, the effect on the Shiro set was negligible. In another orchard there were five rows of Burbank alongside five rows of Shiro. The Burbanks set so heavily that the fruit hung in ropes while the Shiro trees bore practically no fruit. In a third orchard there was a long row of Shiro trees. Right alongside was a part row of Burbank with Reine Claude completing the row. Here it was observed that practically no Shiro fruit set until down near and alongside the Reine Claude trees where a good commercial crop was obtained.

Following the appearance of the article in Canadian Horticulture and Home Magazine, many other substantiating reports have been received confirming the discovery that Burbank and Shiro did not make a satisfactory orchard combination because of the non-setting of the Shiro. Commercially therefore, even though Burbank and Shiro bloom at the same time it is recommended that, if these two are planted, a third variety such as Abundance or Red June be planted to insure the setting of Shiro. Judging from present observations, Reine Claude, Lombard, or probably any other early blooming Domestica plum will also act as a satisfactory pollinator.

To check on a satisfactory pollen variety to plant with Shiro some hand pollination tests were made in 1934 in a Shiro orchard. As the weather was very unfavourable no significant results were obtained, but from this work there was a suggestion that where Burbank pollen was used the fruit set as well as elsewhere. In 1935, the work was continued under controlled conditions. A large Shiro tree about 27 years old was covered.

[1] Read before a meeting of the Horticultural Group of the C.S.T.A., at the University of Saskatchewan, Saskatoon, Sask., June 28–30, 1937.

[2] Assistant in Hardy Fruit work.

[3] Shiro although introduced as a cross of *Prunus Simonii* × *Prunus triflora* (Salicina) × *Prunus Cerasifera* × *Prunus Munsoniana* has all the characteristics of a Japanese variety and seems to be generally accepted as such. Hedrick (Cyclopedia of Hardy Fruits, 1921) lists it as *P. Simonii* × *P. salicina*.

A frame was built large enough to include the whole tree and covered with a good grade factory cotton such as is used in the regular plant breeding work.

No emasculating was done but several limbs were left untouched as check, and also 1,000 pollinations were made with Windsor cherry pollen. Since no fruit set in either case, it can safely be assumed that any fruit which set on the treated limbs was the result of the hand-pollination, and not the result of accidental selfing.

The following table shows the results:

Cross	Pollinations	Fruits matured	Seeds* planted	Seeds germinated
Shiro × Burbank	750	152	93	35
× Lombard	1000	71	19	3
× Red June	800	140	80	22
× Reine Claude	1000	154	10	1
× Windsor Cherry	1000	—	—	—

* In all cherry and plum breeding at this Station the seeds are placed in a pail of water and all those which float are discarded. Past experience has shown these to be non-viable. This accounts for the difference between the number of fruits gathered and the number of seeds planted.

Two things of interest are indicated in this table. First, that Burbank hand-pollinated on Shiro not only pollinates the variety but fertilizes it as well as indicated by the number of seeds planted and germinated. The Domestica varieties, particularly Reine Claude, give a good set of fruit but apparently fertilization does not follow. This lack of fertilization is substantiated in Plums of New York (Hedrick) where as far as can be ascertained only one variety, Burbank No. 7, is definitely listed as a cross of Triflora × Domestica. Two others, Burbank No. 11 and Satuland, are listed as Triflora × Domestica? July 4th is listed Domestica? × Triflora × Americana.

As indicated earlier, literature on the pollination of the Shiro plum seems to be lacking. The writer has made enquiries among several experiment station workers and here again there was no information on the subject. Following these enquiries, Mr. O. Einset of the Agricultural Experiment Station, Geneva, N.Y. made some crosses on Shiro. He also found that Shiro sets freely when hand-pollinated with Burbank pollen.

SUMMARY

Under orchard conditions Shiro growing beside Burbank is not cross-pollinated by that variety. Shiro hand-pollinated with Burbank sets well. No explanation as to the reason for this difference is offered. Further pollination tests are being planned with these varieties with the hope that some explanation may be found. Shiro sets freely with Reine Claude and Lombard, two Domestica varieties, but hybrids between *Prunus salicina* and *Prunus domestica* appear to be rare. The number of viable seeds and number of seeds germinating from the Shiro × Reine Claude or Lombard crosses indicate that although pollination may occur, fertilization rarely follows.

Résumé

Pollinisation de la prune Shiro. George H. Dickson, Station expérimentale d'horticulture de l'Ontario, Station de Vineland, Ontario.

Dans les conditions de verger, les pruniers Shiro poussant à côté des Burbank ne sont pas pollinisés par cette variété, tandis que la pollinisation à la main, avec du pollen de Burbank, est suivie d'une bonne nouure. Aucune explication ne peut être donnée pour cette différence. On se propose de faire de nouveaux essais de pollinisation sur cette variété dans l'expoir de trouver une explication. Le Shiro se pollinise très bien avec la Reine Claude et la Lombard, deux variétés domestiques, tandis que les hybrides entre *Prunus salicina* et *Prunus domestica* paraissent être rares. Le nombre de semences viables et le nombre de semences germant après le croisement Shiro x Reine Claude ou Lombard, indique que si la pollinisation se produit parfois, elle est rarement suivie de fertilisation.

SOME FACTORS IN DELPHINIUM SEED GERMINATION[1]

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Miss Barton's work (1) at the Boyce Thompson Institute has shown that in order to preserve the seedling-producing power of perennial delphinium seed it should be stored in sealed containers in a cool storage place.

The procedure at the University of Alberta has been to store locally produced, perennial delphinium seed in a sealed container in a refrigerator at 36° to 38° F. immediately after harvest and leave it there until planted in flats in a greenhouse in March. Imported seed has been stored similarly as soon as received and planted at the same time as local seed.

Table 1.—Germination of imported *vs.* local cross-pollinated delphinium seed

Source	No. days to germinate	Number seeds	Number seedlings	Percentage germination
Imported seed	9	3,485	1,569	44.5
Local seed	9	1,363	864	63.4

Delphinium seed harvested from cross-pollinated plants at Edmonton has resulted in 63.4% germination as against 44.5% for imported cross-pollinated seed, a difference of 18.9% in favour of Alberta seed. The imported seed consisted of 12 packets from 6 leading sources in England and the United States, there being no appreciable difference in germination of seed from the various sources. Although a number of factors may enter into the problem, it seems likely that the handling of packets incident to the shipment of imported seed has reduced the germination, or that seed produced at Edmonton is more highly viable than that from the other sources. In support of the latter viewpoint is the highly significant fact that the germination of seed produced at Edmonton is higher than that consistently reported in Miss Barton's work, and there is about as much difference as Miss Barton has shown between the perennial and the annual delphiniums.

All the seed reported on in this study was planted in flats, which were partly filled, in the usual way with soil. Then a ¼-inch layer of local peat was applied, the seeds sown in the peat, and enough peat added to cover the seeds. With this procedure, damping off has been negligible.

Table 2.—Quick *vs.* slow germinating delphinium seed lots

No. days to germinate	Number seeds	Number seedlings	Percentage germination
7	1,890	1,100	58.2
12	315	133	42.2

[1] Presented before a meeting of the Horticultural Group of the C.S.T.A. at the University of Saskatchewan, Saskatoon, Sask., June 28–30, 1937.

[2] Professor of Horticulture.

For some unknown reason, certain lots of seed, irrespective of their source, have germinated sooner, or later, than the nine days required for the majority of lots. The number of seeds being known in each case, it is possible to show the respective percentages, which are 58.2% for lots which germinated in 7 days and 42.2% for lots which required 12 days (Table 2), a difference of 16.0%.

It was thought that the explanation of the difference in germination in Table 2 might be due to a difference in size of seeds. Consequently, the large and the small seeds in several packets were separated and planted. In Table 3, it will be noted that the lots of seed selected as large and small, respectively, both germinated in nine days, the same length of time. Although the large seed did not germinate any sooner than the small seed, the percentage germination was higher; 48.4% for large seed and 32.7% for small seed, a difference of 15.7%. Figures are not available for the percentage germination of small local seed, but large local seed germinated 61.2% as compared with 48.4% for large imported seed, a difference of 12.8%.

TABLE 3.—GERMINATION OF LARGE *vs.* SMALL DELPHINIUM SEED

Source and size	No. days to germinate	Number seeds	Number seedlings	Percentage germination
Imported seed:				
Large seed	9	401	194	48.4
Small seed	9	159	52	32.7
Local seed:				
Large seed	9	227	139	62.1

The lots purchased are regarded as the best available, and it may be that the more highly bred seeds are, the more sensitive they will be to adverse conditions. However, the seed saved at Edmonton is from hand cross-pollinated seedlings which are considered as highly bred and outstanding in a collection of 3,500 plants.

SUMMARY

This report, developed incidentally or as a secondary consideration, sets forth the following points:

1. Seed produced at Edmonton gave 18.9% higher germination than seed imported from six leading sources in England and the United States.

2. Seed which germinated quickly (in seven days) gave 16.0% higher germination than seed which germinated slowly (in 12 days).

3. Large and small seed germinated in an equal length of time, but large seed gave 15.7% higher germination than small seed, and large local seed gave 12.8% higher germination than large imported seed.

REFERENCE

BARTON, L. V. Effect of storage on the vitality of delphinium seeds. Contr. Boyce Thompson Institute 4 : 141-153. 1932.

Résumé

Quelques facteurs dans la germination des semences de Delphinium. J. S. Shoemaker, Université de l'Alberta, Edmonton, Alta.

Ce rapport, développé fortuitement ou à titre de considération secondaire, expose les points suivants: 1. La semence produite à Edmonton a donné une proportion de graines germées de 18.9 pour cent plus forte que la semence importée de six lieux principaux de production de l'Angleterre et des Etats-Unis. 2. La semence qui a germé rapidement (en 7 jours) avait une proportion de graines germées de 16 pour cent plus forte que la semence qui a germé lentement (en 12 jours). 3. Les graines grosses et petites ont mis le même temps à germer, mais les grosses graines avaient une proportion de graines germées de 15.7 pour cent plus forte que les petites, et les grosses graines de la localité avaient aussi une germination de 12.8 pour cent plus forte que les grosses graines importées.

CORM BEHAVIOUR IN THE GLADIOLUS IN RELATION TO SEASON OF BLOOM[1]

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In Alberta, the growing season is much shorter than in Eastern Canada, the Pacific Coast, and most parts of the United States. Not only are there fewer growing days on the prairies, but more days are required for a given variety of the gladiolus to bloom. It is the purpose here to explain why late-blooming varieties are not dependable at Edmonton, even though they may bloom well the first year that corms are imported.

The results reported here are based on a study over a two-year period, and have been derived by using material in the Gladiolus Test Garden at the University of Alberta. This test garden was started in the spring of 1935, and has been made possible through the generous co-operation of a number of growers and originators of varieties in Canada, the United States, Europe and New Zealand. In 1935, 213 varieties, which totalled about 1,500 bloom-sized corms, were received for trial. In the spring of 1936, 85 new varieties were received, and the total number of bloom-size corms increased to over 2,000. In 1937, 143 new varieties have been added.

Chances for successful blooming of any variety are greater if the corm planted is high-crowned. This is a rule which has been established by experience. High-crowned corms are of high volume, and therefore high volume can be regarded to some extent as a criterion of quality in a corm. A high-quality corm, will on the average, produce high-quality flowers, whereas one of low quality will not.

The Canadian Gladiolus Society has issued a report in its Quarterly for January, 1936, the result of a symposium held in Ontario, where the growing season is long, and based mainly upon the behaviour of varieties there, in which the season of bloom is classified as follows: Early (less than 75 days); Early midseason (75–80 days); Midseason (80–85 days); late midseason (85–90 days); and Late (over 90 days). It was obvious from a study of blooming dates that varieties will bloom in a shorter time in Ontario than will the same varieties in Alberta.

At the University of Alberta, there were no varieties which in the two-year period averaged less than 75 days from planting to bloom. The nearest approach was a variety which averaged 81 days. In general, varieties in the early and early midseason classes require from 5 to 20 days longer at Edmonton than in Ontario. Varieties in later classes require up to 39 days longer to bloom in the west, and most of those which are classified as late will bloom at Edmonton only when started indoors.

The difference between blooming times of late varieties is greater than that between early varieties. This points to still further differences between the growing seasons of Ontario and Alberta. The chief reason for the greater lag in blooming of late varieties is undoubtedly due to the fact that in the latter part of August the nights are cool, and this checks

[1] Presented before a meeting of the Horticultural Group of the C.S.T.A. at the University of Saskatchewan, Saskatoon, Sask., June 28–30, 1937.

[2] Graduate Assistant in Horticulture.

development of these varieties. On the other hand, Ontario nights at the same time are hot and there is less checking effect, so that the same varieties will bloom earlier.

Because of these differences, variations in cultural practices must be made. For instance, planting must be done earlier, and the period over which it can be done is much shorter than that in Ontario. Corms must not be planted more than three inches deep, whereas five to six inches is the recommendation in the east. Mulching with materials such as straw or peat, although practised extensively in the east, is not recommended at Edmonton, for it has been found to retard blooming.

It was found impossible to classify varieties using the system of the Canadian Gladiolus Society, for this would have excluded early and early midseason varieties. It was obvious, therefore, that a reclassification would be necessary for short-season conditions. To do this it was necessary to study the blooming times of varieties in Ontario and Alberta. Only those grown for two years were considered, and these numbered 142. It was found that at Edmonton the early varieties averaged about 10 days longer than the same varieties in Ontario, and the late varieties 20 days longer. The reclassification (Table 1) was therefore made with class intervals of eight days instead of five days as in the eastern classification. On this basis, the varieties were found to segregate themselves fairly evenly into the various classes with the exception of the early group which included only ten varieties. The number of varieties in the other classes varied from 28 to 36. Because of this reasonably even distribution, it is thought that such a system can be applied to short-season conditions. It is on the basis of this classification that the study on corm behavior is made.

Table 1.—Reclassification of seasons of bloom for gladiolus varieties under Alberta conditions

Season of bloom	Canadian Gladiolus Society	University of Alberta
Early	Under 75 days	85 days and under
Early midseason	75–80 days	86–93 days
Midseason	80–85 days	94–101 days
Late midseason	85-90 days	102-109 days
Late	Over 90 days	110 days and over

To study the probable effect of season of bloom upon corm quality in a short-season environment, measurements were made of about 5,000 corms. All varieties were measured as to width and depth, and their volume computed. The average volume of corms within each variety was calculated, and this figure serves as a means of comparison. It is realized that this figure only approximates the cubic contents. It assumes the corm to be cylindrical and does not consider the rounding off at the top and bottom. It was impossible, also, to always measure the exact width and depth, because of irregularities in shape. An average was recorded in all cases as accurately as possible. The sum of the average volumes was computed for all varieties in each seasonal group for Spring, 1935, and Fall, 1936, as indicated in Table 2.

TABLE 2.—PERCENTAGE GAIN OR LOSS OF CORMS OF EARLY, EARLY MIDSEASON, MIDSEASON, LATE MIDSEASON, AND LATE VARIETIES AFTER TWO YEAR'S GROWTH

Season of bloom	Total volume, spring 1935, cu. in.	Total volume, fall 1936, cu. in.	Percentage gain or loss (−)
Early	16.34	17.38	6.4
Early midseason	54.63	61.48	12.5
Midseason	59.36	65.92	11.1
Late midseason	53.36	55.33	3.7
Late	38.63	33.29	−13.8

Corm formation is a "short-day" process and occurs mainly towards the latter part of the summer during and after blooming. As early varieties have the longest time to mature corms, it was expected that in this group the greatest gain would occur, and that in the late group would be found the least gain, or even a loss. In the former, however, there was a smaller increase than was the case with the Early midseason group. This may well be accounted for by the fact that only ten varieties were included in the early group. Had there been more, it is believed the gain would have been greater. In general, the results were in accordance with expectations and, with the exception just mentioned, there was a decrease in corm quality as the season of bloom advanced (Table 2).

It is seen that in the late class there is actually a loss in average corm volume at the end of two years. Of 28 varieties in this class, only five maintained or increased in volume of corm. Since corm volume is considered the main criterion of probable success, such a decrease shows conclusively that late varieties cannot be grown satisfactorily over a period of years in a short-season environment.

ACKNOWLEDGMENT

Grateful acknowledgment is made to Dr. J. S. Shoemaker, head of the Department of Horticulture, University of Alberta, for advice and suggestions during the preparation of this paper.

SEED GERMINATION OF THE SASKATOON AND PINCHERRY[1,2]

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A collection of wild fruits, now numbering some 580 specimens from 178 sources, was made at the University of Alberta in 1934. Due to the ease of securing material, many of the collections were obtained as seed. The seed samples were usually small and necessitated careful handling to obtain good germination, as well as to solve certain difficulties incurred in germination.

When the study was started little information was available on the germination of the species collected. With the methods used some of the collections did not germinate, and necessitated other tests. This is a report for two of these, namely,—the Saskatoon (*Amelanchier alnifolia*) and the Pincherry (*Prunus pennsylvanica*), which failed to germinate under conditions used for most of the collections.

REVIEW OF LITERATURE

A recent publication (6) from the Department of Horticulture, University of Alberta, discusses the propagation of trees and shrubs from seed, and was prepared in the course of the thesis investigation. That publication may be referred to for certain details on the subject which it seems unnecessary to review here.

Crocker (1) maintained that dormancy in seed is associated with factors such as the following: (a) Inhibition due to one or more of the processes which accompany germination, as the growth of the embryo or the physical character of the seed coat; (b) Seed coat failing to enter into both primary and secondary dormancy; (c) After-ripening processes which involve growth of the rudimentary embryo; fundamental chemical changes in a mature embryo, or chemical changes in the seed coat, a relationship between embryo dormancy and seed coat.

Crocker (3) pointed out that stratification refers to the old method of placing seeds and sand in successive layers and exposing them to cold or freezing conditions. After-ripening is brought about by placing the seeds in a suitable medium and holding them at a certain definite temperature. He further stated that the function of the medium is to give optimum moisture and air conditions to the seeds while being held at the desired temperature. Sand, peat, or soil, fulfil the requirements, if they are free from injurious substances. In general, peat is best, as it holds a large percentage of water and still supplies good aeration.

Crocker (2) stated that all work, up to that time, established that rosaceous seeds did not require freezing to complete the dormancy period and that freezing will not bring about after-ripening.

[1] Presented before a meeting of the Horticultural Group of the C.S.T.A. at the University of Saskatchewan, Saskatoon, Sask., June 28–30, 1937.

[2] This paper is an extract from a Thesis presented in partial fulfilment of the requirements of the Degree of Master of Science at the University of Alberta, the title of which is "Wild Fruits of the Prairies, their Characteristics and sources, propagation and cytology".

[3] Assistant Superintendent.

Crocker and Barton (4) found that seed of *Amelanchier canadensis* germinated best after four months of after-ripening at 1° C. and 5° C. After four months the seed started to germinate at the low temperature.

Giersback and Crocker (5) in experiments with wild plum seed (*Prunus americana*), obtained better germination with a shorter period of after-ripening (less than four months) when the seed was stored at room temperature before stratification.

MATERIALS AND METHODS

During the summer of 1935 seed of Saskatoon and Pincherry was gathered. Care was taken to see that the seed was fully matured. It was immediately washed from the pulp. That of the Saskatoon was divided into two groups. One group was stratified on August 17 and the remainder kept as checks. The seed of Pincherry was divided into four groups. These were treated on August 13th as follows:

(*a*) The first group was after-ripened in the refrigerator;

(*b*) The second was after-ripened in the root cellar;

(*c*) The third group was stored dry until November 14, at which time it was stratified and after-ripened in the refrigerator;

(*d*) The last group was kept dry for checks.

The seeds were placed between layers of cheese cloth, in granulated peat, in petri dishes, all previously autoclaved for six hours. The peat tested pH 5.5. The seeds were examined periodically for mold and moisture content. Mold that did appear was washed from the peat. Refrigeration was electrically controlled and a temperature of 1½° C. to 3° C. was maintained. The temperature in the root cellar varied from 2° C. to 4° C., but was constant at 3½° C. during the greater part of the time. At intervals of one month the desired number of seeds, of each group, were removed from stratification. These were planted in plots, exposed to temperate greenhouse conditions, and germination recorded.

RESULTS WITH SASKATOON AND PINCHERRY

Results of germination tests conducted during the period 1935–36 are summarized in Table 1.

TABLE 1.—PERCENTAGE GERMINATION OF SASKATOON AND PINCHERRY SEEDS TESTED DURING THE WINTER OF 1935–36

Species	Treatment	Temp., °C.	Date of sowing	Months of after-ripening								
				1	2	3	4	5	6	7	8	9
P. pensylvanica	Refrigerator	1½–3	Aug. 13	0	0	0	0	0	0	0	0	0
P. pennsylvanica	Root cellar	2–4	Aug. 13	0	0	0	0	0	0	0	0	0
P. pennsylvanica	Dry to Nov. 14 and refrig.	1½–3	Nov. 14	—	—	—	0	0	2	4	12	34
P. pennsylvanica	Check		Aug. 14	0	0	0	0	0	0	0	0	0
A. alnifolia	Refrigerator	1½–3	Aug. 17	0	0	0	0	0	0	95*	—	
A. alnifolia	Check		Aug. 17	0	0	0	0	0	0	0	0	—

*Estimated. The seeds germinated in stratification, hence they could not be counted without damage to the roots.

With the Saskatoon no germination occurred in either check or treated groups until after the end of the sixth month. When the seed was examined at the end of the seventh month it had germinated. Germination had taken place in refrigeration at a temperature between 1½° C. and 3° C. at some time during the seventh month. The root tips, at the time of examination, had just emerged. None of the four Pincherry groups showed any germination up to the end of the fifth month. The checks and the two groups stratified immediately on being picked had not given any germination at the end of the ninth month. The group stored dry until November 14th, and then stratified and after-ripened in the refrigerator started to germinate after the sixth month, and at the end of the ninth month had reached 34%. The kernels and embryos in all groups were in good condition and the embryos in those stored dry had not shrunken visibly.

DISCUSSION OF SEED GERMINATION

Working with seed of *Amelanchier canadensis* (L.) Medis, Crocher and Barton (4) found germination took place at temperatures of 1° C. and 5° C. after four months of after-ripening. *A. alnifolia* required a much longer period (200 days) of after-ripening at 1½° to 3° C., which emphasizes that requirements vary with the species. The checks, which were not after-ripened, did not germinate. Furthermore, the tests have indicated that care must be taken to watch and remove the seed as soons as germination starts under the low temperatures. These results explain the difficulties experienced by nurserymen in obtaining a stand of Saskatoon from seed. They sow the seed as soon as ripe, the ground freezes shortly afterwards, with a lowering of the temperature below that at which the seed is best held, and the consequence is that the after-ripening process is retarded. Between break-up in spring and the coming of warm days there is not a sufficient period of time with temperatures between 0° C. and 5° C. to complete the after-ripening process. The seed, as a result, lies dormant for another season and completes the process only when the soil temperatures become suitable. This would possibly occur the following spring, irrespective of climatic conditions, with the resultant death of the seedlings in many cases.

An initial three-month dry-storage period before stratification hastens the germination of *P. pennsylvanica*. Giersback and Crocker (5) found that seed of *P. americana* improved in germinating capacity, if stored dry before stratifying, over that of seed stratified as soon as harvested.

SUMMARY

1. When the period of after-ripening has been completed, seed of Saskatoon and Pincherry will germinate at the low temperature of 1½° C.

2. If not removed from the stratification medium soon after germination the seedlings will perish.

3. Dry storage, at room temperature, shortens the rest period of the Pincherry.

4. Saskatoon gives good germination after 200 days of after-ripening.

ACKNOWLEDGMENT

Grateful acknowledgment is made to Dr. J. S. Shoemaker for helpful advice and constructive criticism during the investigation and preparation of the manuscript.

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Résumé

Germination de la semence de l'amélanchier (Saskatoon) et du cerisier de Pensylvanie (pincherry). P. D. Hargrave, Station provinciale d'horticulture, Brooks, Alta.

A la fin de la période d'après-maturation, la graine d'amélanchier et de cerisier nain germe à la basse température de 1 1/2°C, mais les plantules qui ne sont pas enlevées du milieu de stratification bientôt après la germination, périssent. La conservation au sec, à la température de la chambre, raccourcit la période de repos du cerisier nain. L'amélanchier donne encore une bonne germination plus de 200 jours après la maturation.

ABSTRACTS

STUDIES ON THE INFLUENCE OF VARIETY AND CULTURE ON THE KEEPING OF CELERY IN COMMERCIAL COLD STORAGE[1]

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ABSTRACT

The importance of the part played by variety and culture in the storage life of any specific crop of a perishable nature has always been strongly emphasized. Definite information in this respect with regard to celery is very meagre. This being the case experiments were outlined in 1933 by the Macdonald College Muck Soil Committee, for the purpose of studying under Quebec conditions the influence of the variety, of different levels of nitrogen and of spraying *vs.* not spraying, on the growth of celery in the field, and on the keeping quality of the crop when placed in cold storage for winter sale.

All results were statistically analysed and support the following conclusions.

1. Significant differences were found between fertilizer treatments (0-8-10, 2-8-10, 4-8-10, 6-8-10, 8-8-10) and varietal tests Golden Plume, Golden Phenomenal, Golden Self Blanching, tall strain, Golden Self Blanching, dwarf strain, on a basis of weight of marketable plant remainder.

2. These significant differences were not as marked at harvest as at the end of the storage period, although they were of the same general trend.

3. Among the fertilizer tests treatment 5 (8-8-10) was significantly greater than any of the others, and in general the advantage of weight of any one treatment over another at harvest was maintained until after storage. Exceptions were treatments 4 (4-8-10) and 2 (0-8-10); treatments 3 (2-8-10) and 1 (0-0-0), where the significant differences at harvest became lost after storage. Treatments 2 (0-8-10) and 3 (2-8-10) showed no significant difference either at harvest or at the end of the storage period.

4. Varietal differences present at harvest became severely depressed after storage. Golden Self-Blanching, tall strain, was however significant when compared with Golden Self-Blanching, dwarf strain, but no longer different from Golden Plume and Golden Phenomenal, even to odds of 19 : 1. Golden Self-Blanching, dwarf strain, was still significantly lower than the other three varieties with odds of 19 : 1.

5. Pithiness studies showed significance between all treatments and between all varieties.

6. The degree of pithiness appeared to decrease with nitrogen increase, although it was higher in the highest nitrogen treatment than it was in the one immediately below.

7. Varietal comparisons of pithiness indicated that the Golden Self Blanching strains (tall and dwarf) showed less than the Golden Phenomenal and Golden Plume, which were somewhat severely reduced by pithiness. These latter varieties are evidently not suitable for storage purposes.

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[1] Abstract read before a meeting of the Horticultural Group of the C.S.T.A. at the University of Saskatchewan, Saskatoon, Sask., June 28–30, 1937.
Reported from experiments conducted under the direction of the Macdonald College Muck Soil Committee 1932–35. A complete report of the more important phases of investigations with celery grown on muck soils for cold storage purposes, is contained in a master's thesis, which has been presented to the graduate school, McGill University, in partial fulfilment of the requirements for the degree of Master of Science.

[2] Graduate student in Horticulture, 1933–35, specializing in vegetable crops.

SOME INVESTIGATIONS WITH REGARD TO THE EFFECT OF NITROGEN ON THE STORAGE QUALITIES OF CELERY[1]

LEOPOLD BOURQUE[2]

Macdonald College, P.Q.

ABSTRACT

The production of celery for cold storage offers good possibilities to quite a number of Quebec growers because of the quantities which, up to date, have had to be imported yearly, and the presence in the province of large tracts of excellent muck soil which is ideally suited to the production of this vegetable. However, in view of the almost total absence of scientific information necessary for the successful production and storage of this crop, growers have experienced great losses. Certain experiments were planned for the purpose of enlightenment on these problems, with the hope that the production of celery may, in the future, be carried out with less chance of failure. Evidence has been presented to show that under the conditions of this experiment, nitrogen applied to the soil in varying amounts up to 14% of the fertilizer mixture, gave the following results:

1. The yield of celery growing on muck soils was not increased by increasing the nitrogen content of the fertilizer from 0 to 14%, the phosphorus and potash content remaining constant, 8 and 10% respectively. Furthermore, there was no change in size of plant as measured by weight, diameter and height of plants.

2. With regard to wilting in cold storage no significant difference was noted between lots of celery from different nitrogen plots. Dry matter determinations likewise showed no significant differences between plots.

3. Celery from the different nitrogen plots showed similar physical storage qualities, pithiness, breakdown of leaves and petioles, etc.

4. Varying the nitrogen content of the fertilizer mixture did not change the total nitrogen content of the plant as no significant differences existing in quantities of total nitrogen in plants from different plots as determined by the Kjeldohl method. Only slight decreases were noted in the plants throughout the storage period. This decrease was uniform in celery from all plots throughout the storage period.

5. Hexose sugars increased gradually until the end of the storage period, while sucrose sugars showed a slight decrease.

6. It was concluded that the period of economical storage was 90 to 100 days under the conditions of this experiment.

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[1] Abstract read before a meeting of the Horticultural Group of the C.S.T.A. at the University of Saskatchewan, Saskatoon, Sask., June 28–30, 1937.

Condensed from a master's thesis which has been presented to the graduate school, McGill University, in partial fulfilment of the requirements for the degree of Master of Science.

[2] Graduate student in Horticulture 1936–37, specializing in vegetable crops.

MODIFIED EQUIPMENT AND METHODS FOR THE ROUTINE MALTING TEST AND A STUDY OF ITS PRECISION[1]

J. Ansel Anderson[2] and Harry Rowland[3]

National Research Laboratories and University of Manitoba

[Received for publication August 5, 1937]

The equipment and methods used for making malting tests at the University of Manitoba were described in 1932 by Harrison and Rowland (6). Since that time the methods have been modified and during the past few months a new steep tank and kiln have been built and several changes have been made in the germination chamber. The equipment is now being used in a number of different investigations, and since publication of the results of these is anticipated, it seems advisable to prepare for subsequent papers by presenting a description of the modified equipment and methods and the results of a study of the precision of the routine malting test.

EQUIPMENT

Steep Tank

A drawing of the steep tank is shown in Figure 1. The galvanized iron tank is insulated with cork and enclosed in a wooden box which is supported on an angle-iron stand. It is provided with a water inlet and float valve *A*, an overflow pipe *B*, a drain pipe *C*, and a stirrer *D*. The water is cooled by an evaporator *F* which is connected to a $\frac{1}{4}$ H.P. compressor (not shown in the figure). The temperature is controlled to $\pm 0.2°$ F. by means of the thermoregulator *E*, a sealed mercury in glass type, which operates through a relay to act as a switch for the motor which drives the compressor. The tank accommodates 18 quart sealers in which the barley is steeped.

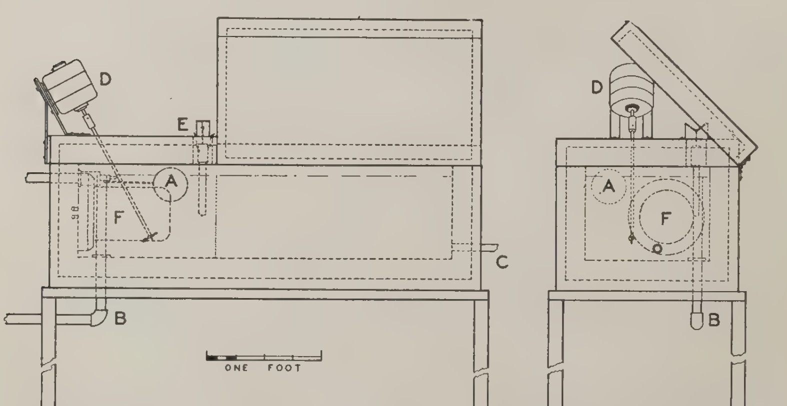

Figure 1. Steep tank.

[1] Contribution from the Malting Laboratory, University of Manitoba: with financial assistance from the National Research Council and the Dominion Department of Agriculture. Published as Paper No. 120 of the Associate Committee on Grain Research.
[2] Biochemist, Division of Biology and Agriculture, National Research Laboratories, Ottawa.
[3] Research Assistant, Department of Agronomy, University of Manitoba, Winnipeg.

Germination Chamber

A drawing of the wooden, cork-insulated, metal-lined germination chamber is shown in Figure 2. Air is driven into the top of the chamber by a fan *A* and passes through a fine spray caused by the nozzle *B* and by the impact of the water on the curved bottom of the air distributing cone *C*. The spray water is drained away through the waste line *D*.

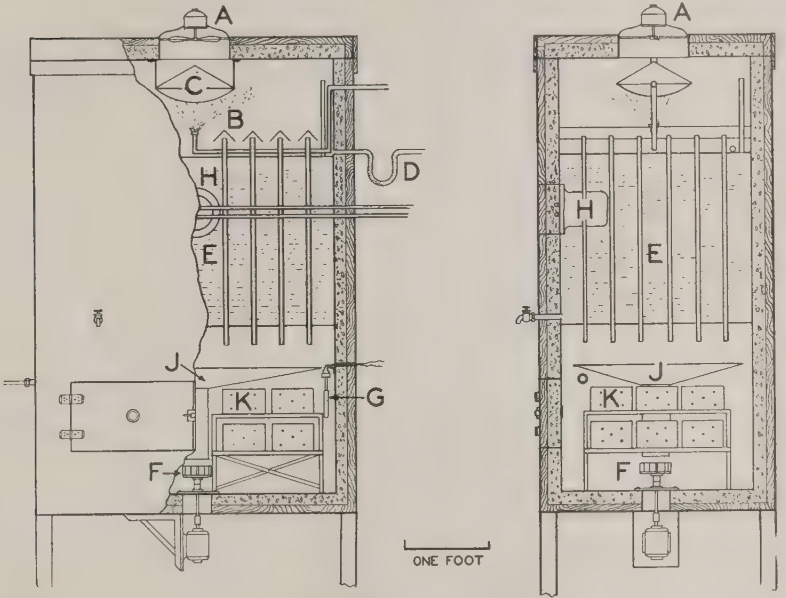

FIGURE 2. Germination chamber.

The air escapes from the spray chamber through forty-eight $\frac{3}{8}$ in. copper tubes which are surrounded by the brine tank *E*. In passing through these tubes the air is cooled to the correct temperature. It then passes into the growth chamber, in which a continuous circulation is set up by means of the small paddle-wheel fan *F*, and subsequently leaves the chamber through holes in the doors and back wall. The temperature of the chamber is controlled by means of the thermoregulator *G* which operates through a relay, as a switch for the compressor motor. When the temperature rises the compressor starts and cools the brine tank by means of the evaporator *H*. As the brine cools, the air passing through the copper tubes is cooled and this in turn cools the thermoregulator and stops the compressor motor. The temperature of the chamber is maintained within $\pm 0.5°$ F. of the set temperature, which is $53.5°$ F.

As a considerable amount of moisture condenses in the copper tubes and on the bottom of the brine tank, a funnel-shaped tray *J* with a 3-in. duct at the centre is provided to prevent the water from dripping on the malt. Since the fan *F* creates a downward draft in the centre duct, the tray also helps to create a definite circulation of the air in the chamber.

The malts are held in galvanized iron boxes *K*. Each box is 6 in. × 6 in. × 4 in., and has thirty $\frac{1}{8}$-in. holes, five in each side, the top and the bottom. The chamber accommodates 24 of these cages.

Kiln

The kiln is similar to those recently installed in the National Research Laboratories, Ottawa (2). A drawing of it is shown in Figure 3. It consists of a galvanized iron inner case and partitions, surrounded by $\frac{1}{2}$-in. asbestos board and 1-in. TenTest, the whole being supported by an angle-iron framework. The inside of the kiln is divided into three parts, a heating chamber, an air distribution chamber, and a drying chamber. The heating chamber consists of an 11-in. × 11 in. chimney located centrally at the back of the kiln. It contains six 100-watt fin-strip heating

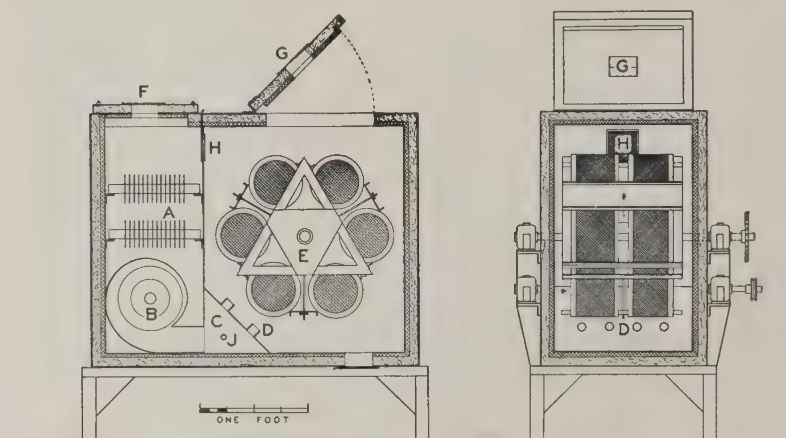

FIGURE 3. Kiln.

elements *A*. A double opening, electrically driven, centrifugal fan *B*, of 30 c.f.m. capacity, draws air downward and past the heating elements and blows it into the air-distribution chamber *C*, from which it is directed on to the malt by eight 1-in. pipes *D*. The drying chamber contains a revolving framework *E* which holds 12 samples of malt contained in cylindrical wire mesh cages. The framework is rotated at a rate of one revolution in 1.25 min. by means of a chain and sprocket drive, a reducing gear, and an electric motor. An air inlet *F* and outlet *G* are provided in the top of the heating chamber and the lid of the drying chamber respectively, and an air vent *H* permits air to be returned from the drying to the heating chamber. Some return air is used during the later stages of kilning in order to keep down the amount of heating required to reach the higher temperatures.

The temperature in the drying chamber is controlled by means of a disc type recording thermometer which has been modified according to the directions given by Binnington and Geddes (5) to form a time-temperature controller. A diagram of the control system is shown in Figure 4. The pen arm *A* operates through a relay *B* and turns the heating element *C*

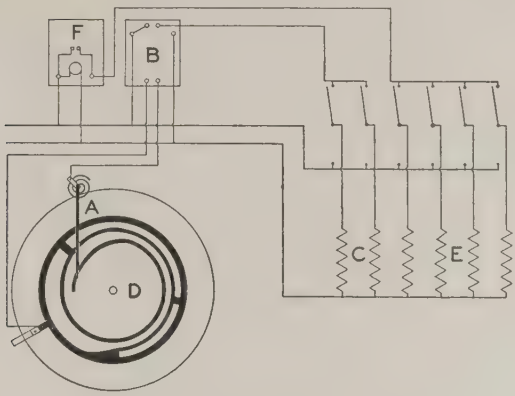

FIGURE 4. Control diagram for the kiln.

on and off by running off and on a copper strip applied to a celluloid disc *D*. The inner edge of the copper follows the time-temperature schedule for the kiln. As the temperature is raised additional heating elements *E* can be turned on either manually or by means of the time switch *F*. The control bulb is inserted into the air distribution chamber of the kiln through a pipe and coupling (Figure 3, *J*).

MALTING METHODS

The barley is prepared for malting by passing it through a small laboratory, ring grader which is provided with a worm feed and which is driven at a constant speed by means of a reducing gear and electric motor.

Duplicate malting tests are made on samples adjusted to a weight equivalent to a 250 gm. of barley dry matter. The samples for any investigation are malted either in random order or according to some scheme which suits the design of the investigation and limits the possible bias due to uncontrollable errors of malting. The malts are made in batches of 12, one batch being put into the germination chamber every Saturday and Wednesday.

The barley is steeped at 50° F. to a moisture content of 46%. The time required is determined by pilot steeping tests. These are made with samples representing 25 gm. of barley dry matter, which are enclosed in small wire mesh cylinders and steeped in sealers in the tank. The cylinders are made with a brass collar at the top by means of which they can be suspended in 100 ml. brass centrifuge tubes. At 48 and 72 hr. the cylinders are taken out of the steep tank and the water adhering to the barley is removed by centrifuging for 1.5 min. at low speed. They are then weighed. From the data thus obtained the time required for the samples to reach a moisture content of 46% is calculated, assuming that the curve obtained by plotting percentage moisture against time can be represented approximately by a straight line.

The main samples are steeped in closed quart sealers. They are aerated once a day by draining off the water and allowing the closed sealers

to float in the tank for one hour before refilling them with fresh water. At the end of the steeping period, the twelve sealers, which form one batch, are drained, fitted with perforated covers, and clamped to a centrifugal wheel. The wheel is rotated at a speed of 180 r.p.m. for 4 min. and the adhering water is thus thrown off the barley. The samples are then transferred to the galvanized iron boxes and placed on the bottom shelves in the germination chamber. Each sample is watered to a moisture content of 48% at 64 hr.; the amount of water required varies between 15 and 25 gm. After 3 days on the lower shelves, the samples are moved to the upper shelves to make room for the next batch. All samples are taken out of the chamber and shaken at 8 a.m. and 4 p.m. daily. The germination process is completed in 144 hr.

The samples are then transferred to cylindrical wire mesh cages and placed in the kiln. The kilning schedule now in use is as follows: 0 to 6 hr., continuous rise in temperature from 85° to 120° F.; 6 to 22 hr., at 120° F., 22 to 30 hr. continuous rise from 120° F. to 150° F.; 30 to 40 hr. at 150° F.; 40 to 42 hr., continuous rise from 150° F. to 175° F.; 42 to 46 hr. at 175° F.

When the sample is removed from the kiln it is kneaded in a small bag for one minute. The roots which are rubbed off by this process are removed by sifting and the finished malt is stored in air-tight sealers.

ANALYTICAL EQUIPMENT AND METHODS

The laboratory now has all the standard equipment required for the analysis of malt, including an electrically heated and mechanically stirred mash bath and a Seck mill.

The following determinations are made: percentage heavy grade barley which is determined with a ring grader; malt yield which is calculated from the weights of the barley and the resulting malt; moisture, extract (fine grind), and colour, which are determined by the Official Methods of the American Society of Brewing Chemists (1), and diastatic power which is determined by a modification of the Official Method (4).

Growth is determined by counting out 100 kernels and estimating for each the length of the acrospire in tenths of the kernel length. The mean length of the acrospire is reported, to two places of decimals, in terms of the kernel length. This practice was adopted in order to obtain single figure estimates of growth suitable for statistical analyses.

Determinations of the nitrogen content and 1,000 kernel weight of the barley are made in the laboratories which submit samples for malting tests.

It has been the practice to split the 24 malts made each week into duplicate samples and analyze these in random order during the following week. For certain investigations, however, it has been possible to obtain sufficiently precise results by making only one of each determination required on each sample of malt and repeating these only when results for duplicate malts fail to agree closely.

PRECISION

The precision of the malting test and the possible effects on this of minor space variations in the temperatures in the equipment, were recently investigated by making six batches of malt from the same barley. The

samples were prepared with a Boerner sampler and were malted in random order. A record was kept of the position, in the equipment, in which each sample was malted.

Since experience has shown that diastatic power is most sensitive to variations in malting conditions the complete data for this determination are presented in Table 1. The data for the other determinations have been summarized in Table 2 as means, over all batches, for each position; and in Table 3, as means, over all positions, for each batch.

TABLE 1.—DIASTATIC POWER OF SIX BATCHES OF MALT MADE FROM THE SAME BARLEY

Position in chamber	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Mean
1	116	114	116	117	118	115	116.0
2	115	114	116	112	118	114	114.8
3	118	115	117	116	118	113	116.2
4	116	114	114	113	119	114	115.0
5	117	113	115	112	120	112	114.8
6	118	114	116	114	119	110	115.2
7	114	112	115	114	119	113	114.3
8	115	113	114	114	119	113	114.7
9	115	114	116	115	118	114	115.3
10	116	113	116	114	118	113	115.0
11	116	115	118	114	117	114	115.7
12	115	114	114	115	117	113	114.7
Mean	115.9	113.8	115.6	114.2	118.3	113.2	

A study of the data in Table 1 will show that the positions did not maintain the same relations in different batches. In these circumstances it is impossible to determine by inspection whether the differences between means for positions are the result of real differences between positions or merely of fortuitous combinations made possible by random variation within batches. The same observations apply to the results for all other determinations.

In order to solve this problem the variance of the data for each determination was analyzed into portions due to: (i) variations in the general level of results obtained in different batches; (ii) average differences, over all batches, between positions; and (iii) error, *i.e.* differences in the relative performance in different positions in the six batches. The Z test was then applied to determine whether the mean squares due to batches and to positions, respectively, were significantly greater than that due to error. The results of the analyses of variance are reported in Table 4. They show for all determinations that the differences between batch means would occur less than once in 100 trials if they were caused only by fortuitous combinations of random errors. This conclusion also applies to the differences between positions with respect to moisture. For all other determinations differences as great as those between position means would occur more than once in 20 trials merely as a result of combinations of errors. The investigation therefore provides strong evidence that differences exist between batches, but fails to prove that real differences exist between positions except with respect to moisture.

TABLE 2.—MEANS FOR THE TWELVE POSITIONS IN THE EQUIPMENT

—	1	2	3	4	5	6	7	8	9	10	11	12	Range
Extract, %	75.6	75.5	75.5	75.5	75.6	75.5	75.6	75.5	75.6	75.6	75.6	75.6	0.1
Moisture, %	3.47	3.49	3.49	3.48	3.52	3.54	3.58	3.57	3.56	3.62	3.58	3.59	0.15
Colour, units	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Diastatic P., °L.	116.0	114.8	116.2	115.0	114.8	115.2	114.3	114.7	115.3	115.0	115.7	114.7	1.9
Malt yield, %	92.5	93.1	93.1	93.0	93.0	93.2	93.2	93.2	93.1	93.3	93.1	93.0	0.8
Sprouts, %	2.9	2.4	2.4	2.3	2.5	2.4	2.3	2.5	2.4	2.4	2.5	2.4	0.6
Growth	.85	.85	.86	.86	.87	.86	.88	.85	.86	.86	.87	.86	0.03

Examination of the results for moisture given in Table 2 shows that those for positions 1 to 6, which are on one side of the germination chamber, are all lower than those for position 7 to 12 which are on the other side. It appeared that this difference might also have resulted through differences in the two sides of the kiln but experiments showed this hypothesis to be wrong. No explanation has so far been discovered for this curious difference between the two sides of the germination chamber with respect to moisture content of the malt. However, it is not considered a serious source of error since the differences within batches are considerably less than those between batches. This is also true for all other determinations. The conclusion to be drawn is that if improvement of the malting is required, it must be sought first by attempting to reduce the variation between batches. It follows also that under existing conditions it will be possible to obtain more precise comparisons between samples which can all be malted in the same batch.

TABLE 3.—MEANS FOR THE SIX BATCHES

——	1	2	3	4	5	6	Range
Extract, %	75.6	75.5	75.3	75.6	75.6	75.7	0.4
Moisture, %	3.44	3.55	3.58	3.68	3.55	3.45	0.24
Colour, units	1.6	1.6	1.6	1.6	1.6	1.6	0
Diastatic P. °L.	115.9	113.8	115.6	114.2	118.3	113.2	5.1
Malt yield, %	93.1	93.0	93.2	92.5	93.5	93.2	0.7
Sprouts, %	2.2	2.6	2.3	2.9	2.5	2.2	0.7
Growth	.87	.84	.85	.85	.87	.88	0.04

TABLE 4.—ANALYSIS OF VARIANCE

Variation due to	Degrees of freedom	Mean squares		
		Extract, %	Moisture, %	Diastatic power, °L
Batches	5	0.18208**	0.09545**	41.325**
Positions	11	.02792	.01557**	1.428
Error	55	.02316	.00315	1.324
		Malt yield, %	Sprouts, %	Growth
Batches	5	1.9783**	0.86015**	0.00179**
Positions	11	0.2473	0.13741	0.00056
Error	55	0.2454	.16584	.00061

** Significantly greater than the mean square due to error: the significance attains a 1% level.

A concise picture of the precision of the malting test can be obtained by calculating the standard errors for the means of duplicate tests made in the same and in different batches. This has been done and the results for all determinations except colour, together with the standard errors for the means of duplicate analyses, are reported in Table 5. No data are

given for colour since all samples were reported as having a colour of 1.6 units. It will be observed that for extract, moisture and diastatic power, the precision of the test is about equal to that of the analyses. Experience has shown that the precision obtained for all determinations represents a useful level for the investigation of malting quality now being undertaken in Canada.

TABLE 5.—STANDARD ERRORS FOR THE MEANS OF DUPLICATE ANALYSES AND DUPLICATE MALTINGS MADE IN THE SAME AND DIFFERENT BATCHES

Determination	Duplicate analyses	Duplicate maltings	
		In same batch	In different batches
Extract, %	0.10	0.11	0.18
Moisture, %	.06	.05	.08
Diastatic power, °L.	.98	.82	1.53
Malt yield, %	—	.35	.44
Sprouts, %	—	.28	.33
Growth	—	.02	.02

PROGRAM

The laboratory has a staff of four, and duplicate malting tests can be made on 550 samples per year. Tests are being made on samples produced in variety trials, in studies of the effect of cultural practices and fertilizers on malting quality, and in investigations designed to outline more closely the best malting barley areas in Canada. It is hoped that the data collected in these studies will also serve a secondary purpose. When a sufficient body of data has been collected it will be subjected to statistical analysis with the object of setting up prediction equations for the extract yield of Canadian barley varieties, and of examining the relation between barley quality and other malt characters.

SUMMARY

Equipment and methods for a routine malting test are described. They consist essentially of modifications of those devised by Harrison and Rowland (6). Investigation shows that space variations in temperature in the modified equipment are not a serious source of error but that small but significant differences occur in the quality of malts made in different batches. The standard errors of the means of duplicate malting tests made in the same and in different batches are as follows:

Extract, 0.11 and 0.18%; moisture, 0.05 and 0.08%; diastatic power, 0.85 and 1.53° L. (on malt of 115° L.); malt yield, 0.35 and 0.44%; sprouts, 0.28 and 0.33%; and growth 0.02 and 0.02 of kernel length.

ACKNOWLEDGMENTS

The authors are indebted to Mr. D. S. Kaufman of the Dominion Malting Co. Ltd., and to Mr. P. J. Dax of the Canada Malting Co. Ltd., for valuable advice on the development of satisfactory malting methods, and for their continued interest in the work of the laboratory.

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ARMILLARIA MELLEA VAHL EX FR. ON RASPBERRIES IN BRITISH COLUMBIA[1]

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[Received for publication, July 21, 1937]

During a survey of raspberry plantations in the Hatzic district of British Columbia in the summer of 1936, it was observed that many plants were partially or wholly killed in three plantations (Figure 2). When the crowns and roots of such plants were examined, the characteristic rhizomorphs of *Armillaria mellea* Vahl ex Fries were found adhering to them (Figure 4). Mycelial felt of the fungus was also observed beneath the bark of the crowns and main roots. Several thimbleberry plants (*Rubus parviflorus* Nutt.) were also found partially or wholly killed in the Mission district.

In October, another survey was made to determine the extent of the distribution of sporophores of the fungus in the raspberry growing areas of the Lower Mainland of the Province. Twenty plantations were inspected, and sporophores were found in five of them from the five districts of Huntington, Burnaby, Hatzic Island, and Mission. They were prevalent in three-year old, six-year old, as well as plantations over twenty years old. The varieties Cuthbert, Viking, and Lloyd George were affected.

The sporophores were found growing directly on the crowns (Figure 1) as well as on buried tree stumps (Figure 3). They were usually observed on individual plants in different parts of the fields, but in two plantations they were found on several plants adjacent to each other in the rows. At the time of inspection only a few sporophores were seen in some of the plantations but this does not give a true index of the extent of the parasite in the soil. Thus in one plantation in Hatzic Island, numerous plants which had been partially or wholly killed but on which no sporophores were present, were dug up and examined. Several of these had rhizomorphs of the fungus adhering to the roots and crowns. The rhizomorphs were spreading below soil level along the rows and also towards the adjoining rows. In one three-year old unthrifty plantation, a rhizomorph was traced from a sporophore growing from a dead tree stump near a raspberry plant. This emerged about eight inches below the surface, but was growing upwards and spreading at about four inches below soil level for a distance of forty-one inches towards the adjoining row.

The sporophores of the fungus were very prevalent in the woods in the raspberry growing areas and the fungus appears to be widely distributed in the Lower Mainland. Thus far, the fungus has not been observed in any of the raspberry plantations of Vancouver Island.

It has been the practice of some growe o grow raspberries on newly cleared land owing to the high yields produced thereon. This cannot be

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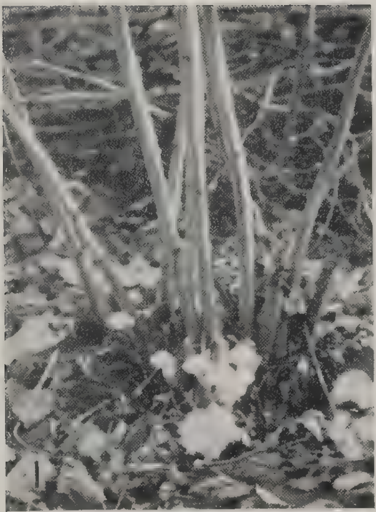

FIGURE 1. Sporophores of *Armillaria mellea* on a Cuthbert raspberry plant, Burnaby, B.C.

FIGURE 2. Cuthbert raspberry plant killed by *Armillaria mellea*, Hatzic, B.C.

FIGURE 3. Sporophores of *Armillaria mellea* on an old tree stump adjacent to a Cuthbert raspberry plant, Hatzic, B.C.

FIGURE 4. Rhizomorphs of *Armillaria mellea* adhering to a dead raspberry root.

considered sound practice when *Armillaria mellea* is known to be present. Huber (1), in his summary of control measures advises "delay in the use of land for tree planting until infection in the soil has died out, estimated at about three years". Thomas (2) claims that "the invasion of the root is accomplished by the penetration of a branch of the parent rhizomorph directly through the sound healthy periderm of the host", thus showing that injury of living tissue is not essential before infection can take place.

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MAJOR PROBLEMS IN FIELD HUSBANDRY[1]

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The President of the Western Canada Society of Agronomists, Mr. G. E. DeLong, has asked me to give a paper at this meeting on Field Husbandry Problems. He said that it was the intention of the Executive to have papers presented which would outline problems rather than give the results of definite experimental work. It is rather difficult to select major problems in Field Husbandry as it is impossible to know for certain what line of work may ultimately prove most important.

Without doubt, the most important general problems in field husbandry in the Prairie Provinces, include those relating to drought, soil drifting, weed control, and insect and fungus diseases. However, these problems are so vast that they must be divided into small component parts in order to be more easily understood and investigated.

Viewed in retrospect, there are many problems at the present time which are the heritage of the past. The Prairie Provinces have been settled throughout the last fifty years without much plan or knowledge of the soil or climate. No one, even the best informed, could know without a soil survey and precipitation records the agricultural possibilities of the various regions. The settlers homesteaded or purchased land without information of its real productive capacity or of its susceptibility to protracted periods of drought. This policy, or rather lack of policy, has given rise to many problems which agronomists must aid in attempting to solve. Compared with most countries throughout the world the agriculture of Western Canada is comparatively in its very early development, and yet its problems are already very serious.

Climatic Problems

Insufficient precipitation is undoubtedly the greatest single factor limiting crop yields. The conservation of soil moisture, therefore, is a very important problem.

Precipitation records alone do not give a true picture of moisture conditions inasmuch as evaporation influences the value of the moisture received. Furthermore, the character of the rainfall has an important influence, too light showers having very little effect, and too intense rainfall being subject to excessive run-off.

The greatest amount of precipitation in the Prairie Provinces is received in the eastern section. Among our Branch Dominion Experimental Stations on the Prairie, Morden has received the greatest precipitation with a total of 19.03 inches. Brandon has almost as much with 18.75 inches. The least precipitation received in the more settled parts of the Prairie is at Scott with a total of 13.47 inches, while Fort Vermilion in Northern Alberta receives the least with a total of 11.68 inches.

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[1] Read before the Western Canadian Society of Agronomy, June 28, 1937, at the University of Saskatchewan, Saskatoon.

[2] Dominion Field Husbandman.

It will be seen that between Scott and Morden, there is only a difference of 5.56 inches. Small, however, as is this quantity of precipitation, it is sufficient to create very different growth conditions even though a substantial amount of this increase is received during the non-growing season.

Evaporation records taken from a standard tank range from 16.19 inches per season at Brandon to 27.74 inches at Swift Current. Lacombe and Beaverlodge also have small amounts of evaporation of somewhat over 16 inches, while Lethbridge, like Swift Current, has high evaporation with approximately 25 inches.

In certain years, however, evaporation records may vary very widely. In 1936, Beaverlodge had only 12.62 inches of evaporation and Lacombe only 15.86 inches, while Swift Current had 37.66 inches and Lethbridge 33.33 inches. It will be seen, therefore, that during extreme years, the differences in evaporation are very much greater than the average and indicate a condition of atmospheric drought greater than normally experienced. It may not be generally realized that in certain years the evaporation in one locality may be twice or three times as much as in another locality on the Prairie.

Even within comparatively short distances considerable differences may arise. For example, between conditions at Rosthern and those at Melfort, very appreciable differences must exist although no long time records are available to show the amount.

Changing Agricultural Views

Over a period of years, a considerable change in opinion develops in regards to certain agricultural practices. It may be of interest to mention merely a few views which during past years have been emphasized to a greater or less extent.

In early years the "small farm, well tilled," was intensively advocated. It is known now that this plan is not suitable for Prairie agriculture and particularly so in the drier regions. The large scale farming operations in Russia during recent years, and the consolidation enactment in Germany of small farms for the purpose of greater efficiency, even so recently as last week, shows the trend of development in large and important countries.

The soil mulch was advocated quite extensively as a means of conserving soil moisture. This was an unfortunate development for which Experimental Stations and Agricultural Colleges must assume a considerable share of the responsibility. It is now known that mulches play very little, if any, part in conserving moisture.

At various times, corn and sunflowers have been quite extensively advocated. An examination of the crop statistics, however, will show that they have not been adopted extensively by farmers and, except in a few regions, do not seem to offer much promise.

Trench silos, a few years ago, were very extensively advocated but, at the present time, very little is heard of this method of preserving feed.

The use of grass and legumes in crop rotations has been suggested but has failed to give profitable returns as compared with grain. Their use is confined to more favoured districts, where better success may be obtained, or in extremely dry regions which may be seeded to permanent pasture.

It is not intended to imply that the previously mentioned agricultural practices may not have some application in certain limited regions. However, any extensive advocacy of practices which are not applicable creates a situation which agronomists should be careful to avoid.

Agronomic Problems

In order to obtain the most recent information in regard to various agronomic problems I have communicated with the staffs of the Branch Experimental Farms in the Prairie Provinces. These officers have very kindly given very full information in regard to a number of field husbandry problems. I thought that a brief examination of some of these views might be of interest.

Summer-fallow Treatments

As there are approximately 14,000,000 acres of land in summer-fallow in the three Prairie Provinces, it is very desirable to learn the most efficient methods of doing this work. It is not my intention to discuss different methods of summer-fallowing which have been under experiment on various Dominion Experimental Farms, because as I have previously mentioned, the subject assigned for this talk was to discuss problems rather than the results of individual experiments. Such results may be obtained in the reports of the Dominion Experimental Farms.

However, there are some questions or problems in connection with summer-fallowing on which differences of opinion exist and which I might raise for your consideration. The following questions would seem to be quite important:

> "Is summer-fallow necessary on all soil types and particularly on sandy soil?"

The answer to this would seem to depend upon a number of factors such as climate, weeds and farm management. In the more moist regions of the Prairie where alfalfa and sweet clover will grow satisfactorily, the land may be ploughed in July and partially summer-fallowed during the remainder of the season. This treatment seems to give quite satisfactory results in the more humid regions, but it is worthless in the drier parts of the Prairie where greater moisture conservation is required.

Where weeds are present in appreciable quantities, and this would seem to be nearly everywhere, the summer-fallow is necessary to clean the land. Clean land provides, moreover, for more efficient conservation of soil moisture.

In order to permit larger acreages to be handled per man or with a certain amount of farm equipment, the summer-fallow is very necessary. It enables the work to be distributed over the season to better advantage and provides land ready for seeding in the spring.

Some think that sandy loam should not be summer-fallowed as it does not conserve sufficient moisture throughout the summer to enable the production of better crops than may be secured on stubble land. If a sandy surface soil is underlaid by clay the use of summer-fallow would seem to be desirable. However, if the sand is underlaid by sand it is quite possible that this land would not conserve sufficient moisture by the summer-fallow to warrant its use. Grave doubts should be entertained, however, as to the wisdom of farming such land, particularly in the open prairie region where precipitation is low and evaporation high.

Another problem of importance is:

> "Should land used for grain be summer-fallowed every second year, every third year, or at longer intervals?"

The answer to this question like the preceding question depends, also, on the climate, weed infestation and the farm management plan followed. In the dry regions the two-year rotation would seem to be the most suitable. Its use gives greater expectancy of a profitable crop particularly in dry years and it permits the handling of quite large acreages.

In the more moist areas summer-fallow may be used at longer intervals although it is a problem to know whether this practice is preferable to the two-year rotation of summer-fallow and grain. Where grass or legumes may be grown successfully, the summer-fallow may be used at longer intervals.

New Tillage Methods

One of the most important tillage problems is to know if the use of the plough should be discontinued on stubble land. As stubble land and summer-fallow constitute about 97% of the cultivated land on the prairie, it is quite an important matter to know the most efficient method of handling such land.

Undoubtedly, at the present time, there is a very marked change towards the use of surface cultivation or discing rather than ploughing. This practice, which is being advocated for the reason that it greatly assists in controlling soil drifting, has also the merit of being more economical and enables more rapid and timely operations.

With some weeds it is very probable that surface cultivation is more effective than ploughing. Possibly with other weeds, such as sweet grass, couch grass or rose bushes, ploughing may be necessary. For most weeds, however, shallow working of the land seems to be preferable to ploughing.

An exception seems to have developed in regard to this view from the Scott Station, where spring ploughing has given two bushels of wheat per acre more than any other method used.

Some think that the plough may be necessary every few years on surface-worked land in order to loosen the sub-soil. It is a problem on which no absolutely reliable data exist, but our experiments do not indicate the necessity of this practice.

In recent years several new tillage methods have been promoted in the dry regions of the United States. These methods include terracing, contour furrowing, contour tillage and basin listing. These practices have been designed with the object of conserving additional soil moisture. In some regions with uneven topography considerable loss of precipitation is experienced, particularly with heavy rainfall. As this type of precipitation is quite common, a very large percentage of the rainfall may be lost from cultivated land. The question of the advisability of using such tillage methods in Canada constitutes problems that would seem to require quite thorough investigation under varying conditions.

Mixed Farming Crop Rotations

While only approximately 3% of the cultivated land in the Prairie Provinces is devoted to hay crops, the question is frequently raised as to whether or not it would be advisable to have more mixed farming rotations

in the Prairie Provinces. This raises a problem which has been much discussed.

Apparently it is only in the more moist regions of the prairie where hay crops will grow satisfactorily and where livestock can be raised to advantage, that this type of rotation can be used.

The use of grass and legumes leaves organic matter in the soil which has some effect in controlling soil drifting. Some difference of opinion exists, however, in regard to the value of certain clovers such as sweet clover, the claim being made by some but contradicted by others, that sweet clover is helpful in controlling drifting. In connection with erosion due to water which has become quite important in certain parts of the prairie, the use of grass and clover crops may be very effective.

Is the Fertility of the Prairie Soil Becoming Seriously Impaired?

With regard to soil fertility, most parts of the Prairie Provinces enjoy a much more satisfactory condition than that which prevails in the humid regions of Canada. Undoubtedly, the soil is much more fertile on the Prairie, and the thought, or at least the hope, has been entertained by some that the fertility would continue indefinitely.

There is some indication that in the more humid parts of the Prairie an appreciable decrease in soil productivity has taken place. In the dry regions this has not been so apparent except where the soil has been damaged by soil drifting.

The more efficient use of farm manure on poor land, knolls and places where the soil is liable to drift, would seem to constitute a better method of utilizing farm manure than applying it to fields which are already fairly productive. Farm manure is very much disregarded in the Prairie Provinces, but its use in the manner indicated would seem to be profitable.

The use of commercial fertilizers where they will give profitable responses, constitutes a problem for experimental stations and for individual farmers. Fairly substantial increases in yields have been obtained on some Dominion Experimental Stations but in the drier regions in the southern portion of the Prairie, profitable increases have not yet been obtained.

The improvement of gray bush soils offers a promising field. The very excellent work of Dr. F. A. Wyatt of the Alberta College of Agriculture, in connection with the use of sulphur, nitrogen, phosphorus and clover on these soils, points the way to very considerable improvement and possibly much greater development of this very extensive soil type.

More Effective Weed Control Necessary

Under the usual system of grain farming, weed control is a problem very much more important than it is in regions where the land is devoted for a number of years to hay and pasture. The losses occasioned by weeds are very difficult to estimate accurately but it would seem safe to assume that in the Prairie Provinces, a 15% loss due to weeds would not overestimate the situation. If this estimate were taken, the loss due to weeds in the Prairie Provinces, in 1936, might be estimated at $43,246,000.

Many problems exist in regard to learning more efficient and economical methods of weed eradication for the various species of weeds which prevail under different soil and climatic conditions.

Soil Drifting Control Methods

Under the Prairie Farm Rehabilitation Program an effort is being made to learn and to demonstrate improved methods of soil drifting control. These methods include strip farming, surface cultivation, cover crops, crop rotations and tree planting. The use of these practices constitute problems for the agronomists. It is necessary to learn what success may be obtained with these measures under different conditions.

At the present time the practice of strip farming with surface cultivation would seem to have proved quite satisfactory in soil drifting control with the exception of its use on very sandy land which is devoid of stubble or trash during periods of extreme drought.

The extension of soil drifting to the Park Belt areas of the Prairie Provinces constitutes a new problem which has been developing in recent years.

The Drought Problem

The disastrous drought which has unfortunately afflicted southern portions of the Canadian Prairie for so many years, constitutes the most serious of all problems to the agronomists. The duration of the drought sometimes gives rise to the fear that it may continue permanently. While a study of the past proves that the present drought will not last forever, it is undoubtedly the longest drought for which records in this country are available.

The serious nature of this drought and the knowledge that similar periods will be experienced again just as they have been in the past, makes imperative the study of improved methods of efficient soil moisture conservation. All angles of this problem must be investigated, the results brought together and used to the best advantage.

The unfortunate condition of the farmer, during periods of drought, has required very large financial contributions by the Provincial and Dominion Governments. These contributions, unfortunately, only partly meet the situation and do not enable the farmer to live on a standard of living during drought periods comparable with those he has enjoyed during better years.

Certain suggestions have been made in this connection, such as crop insurance and more recently, in the United States, the so-called "Ever Normal Granary". This is a problem which is of interest not only to agronomists but to many other classes of society. The difficulty is to evolve a system which is workable and which will not involve unfair contributions from the better class of farmers for the benefit of those who do not work their land properly, or which would require payments from farmers in good districts to those living in regions in which crop failures are more frequent.

Undoubtedly, studies along these lines are very useful. Care should be taken, however, to avoid recommending any plan which would make conditions worse than they are. The study of some system of individual crop savings bank accounts in which each individual would attempt to create a financial reserve to meet possible drought conditions, would seem to offer some promise. It should be associated, to be sure, with the best agricultural practices and the production and storage of home feed and seed supplies.

Conclusion

Problems in agronomy are among the greatest, if not the greatest, of all Canadian problems. They are of a long time character and are not merely of passing interest. Some problems give rise to others; for example, the thorough cultivation necessary for weed control is conducive to soil drifting, which, in turn, results in impaired soil fertility. Similarily, the practice of surface cultivation may give rise to greater possible insect infestation. The problems which I have discussed are but a few of those of major importance.

In recent years the question of land utilization has been brought into greater prominence. It is a subject to which agronomists must give more attention. It is obvious that our land resources cannot be utilized to best advantage until soil scientists classify the land, agronomists learn how crops may be grown to best advantage and, I might add, until agricultural engineers discover the most efficient types of equipment to enable the production of crops at the lowest possible cost.

ERRATA

In the June issue of *Scientific Agriculture* (Vol. 17, No. 10), the names of Mr. K. M. King and Mr. S. H. Vigor appearing at the end of the Summary on page 614 should be transferred to the Appendix on page 615.

In the Book Review of *Canadian Animal Husbandry* on page 592 of the May issue (Vol. 17, No. 9), the price should read \$3.50 instead of \$3.75.